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G1A AA3 AEDP AG17 AR8
U1S S2424

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US 5247137 A US 4513437 A US 4070649 A

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(54) Manual entry interactive paper and electronic document handling and processing system

(57) A manual entry interactive paper and electronic document handling and process system uses a pen-like instrument 91 with a writing point for making written entries upon a physical document 10 and transducers for sensing the three-dimensional forces exerted on the writing tip as well as the motion associated with the act of writing. The instrument 91 is also equipped with a CCD array for reading pre-printed bar codes used for identifying document pages and other application defined areas on the page, as well as for providing optical character recognition data. A communication link 93 between the instrument and an associated base unit 92 transfers the transducer data from the instrument. The base unit includes a programmable processor 94, a display 95, and a communication link receiver. The processor includes programs for written character and word recognition, and memory for storage of an electronic version of the physical document and any hand-written additions thereto. The display unit displays the corresponding electronic version of the physical document on a CRT or LCD as a means of feedback to the user and for use by authorized electronic agents.

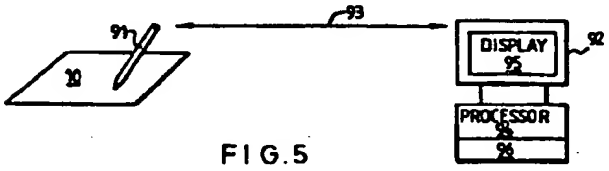

FIG.5

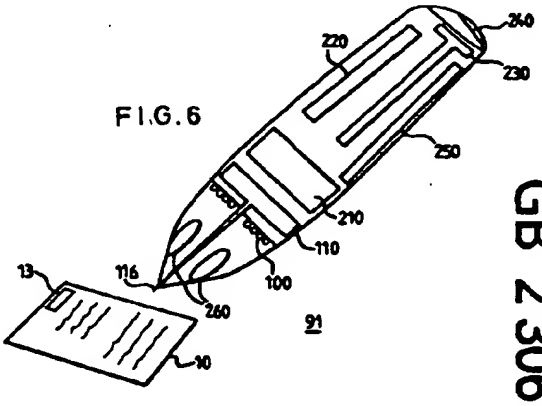

FIG.6

GB 2 306 669 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

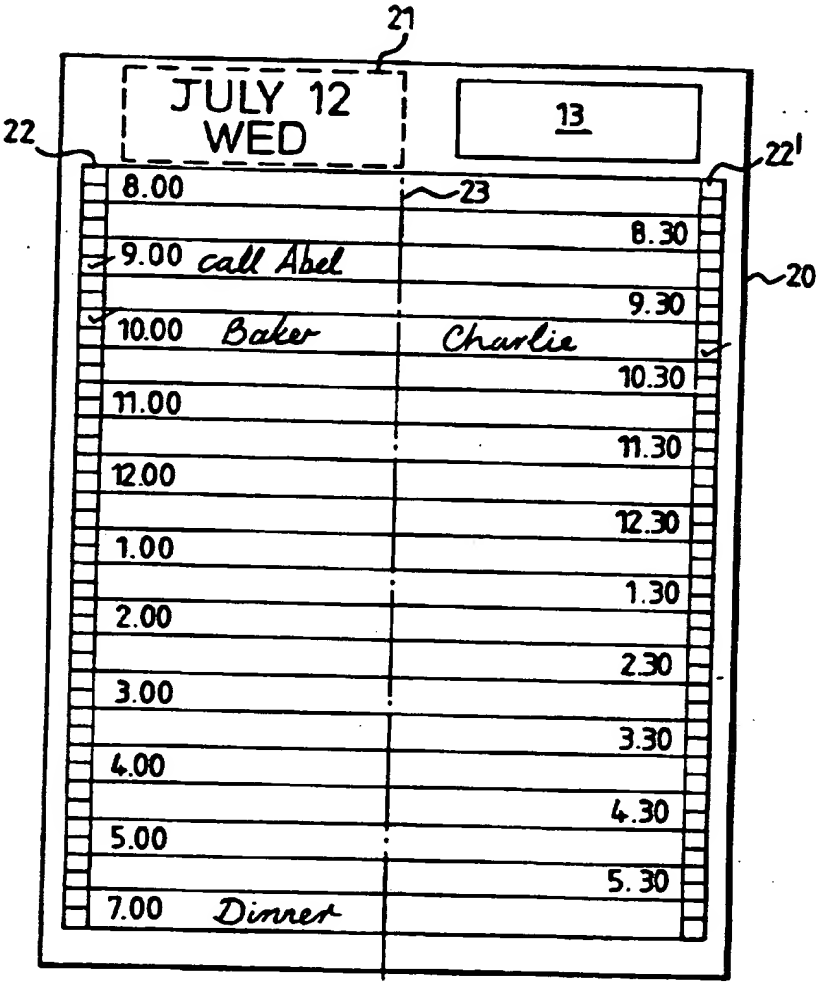
21
JULY 12
WED
13
22
22'
20
23
8.00
8.30
9.00 call Abel
9.30
10.00 Baker
Charlie
10.30
11.00
11.30
12.00
12.30
1.00
1.30
2.00
2.30
3.00
3.30
4.00
4.30
5.00
5.30
7.00 Dinner

FIG.1

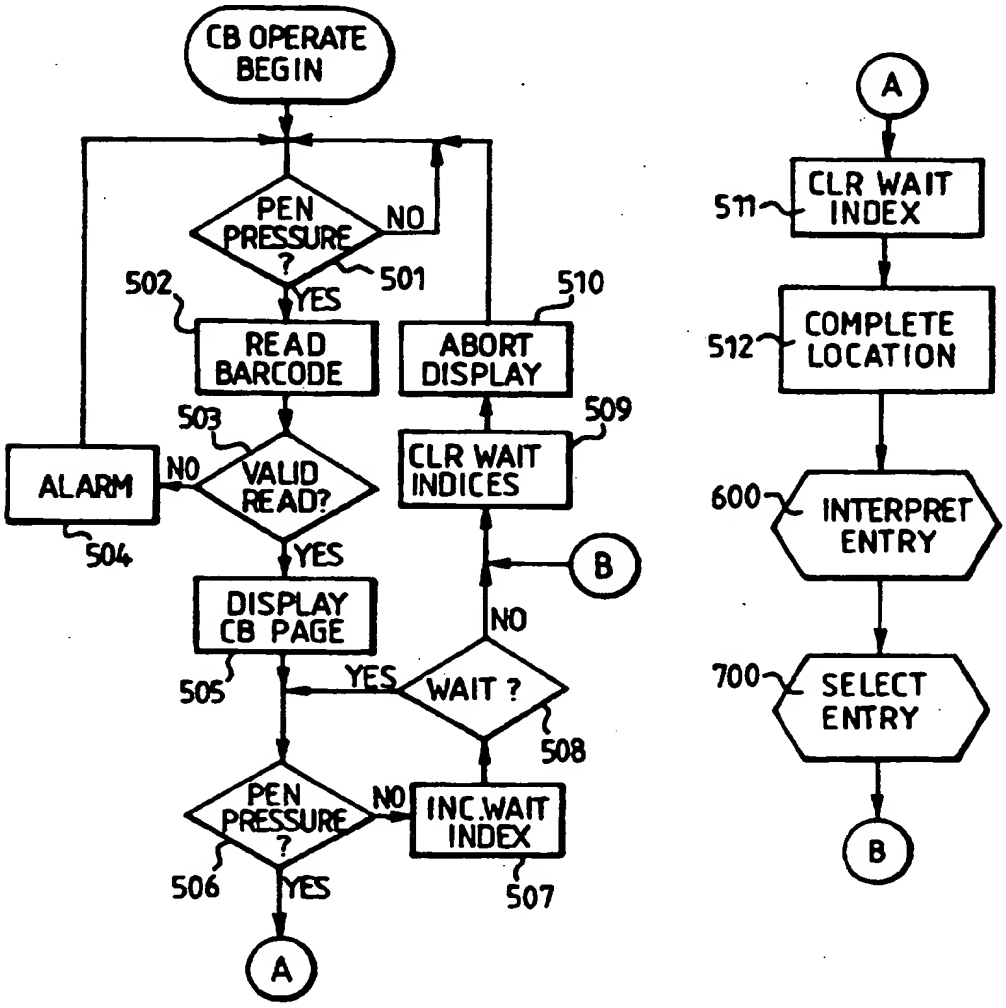
CB OPERATE BEGIN
PEN PRESSURE ?
NO
YES
501
502
READ BARCODE
503
VALID READ?
NO
ALARM
504
YES
DISPLAY CB PAGE
505
YES
WAIT ?
NO
508
510
ABORT DISPLAY
509
CLR WAIT INDICES
B
PEN PRESSURE ?
NO
INC.WAIT INDEX
507
506
YES
A
A
511
CLR WAIT INDEX
512
COMPLETE LOCATION
600
INTERPRET ENTRY
700
SELECT ENTRY
B

FIG 2

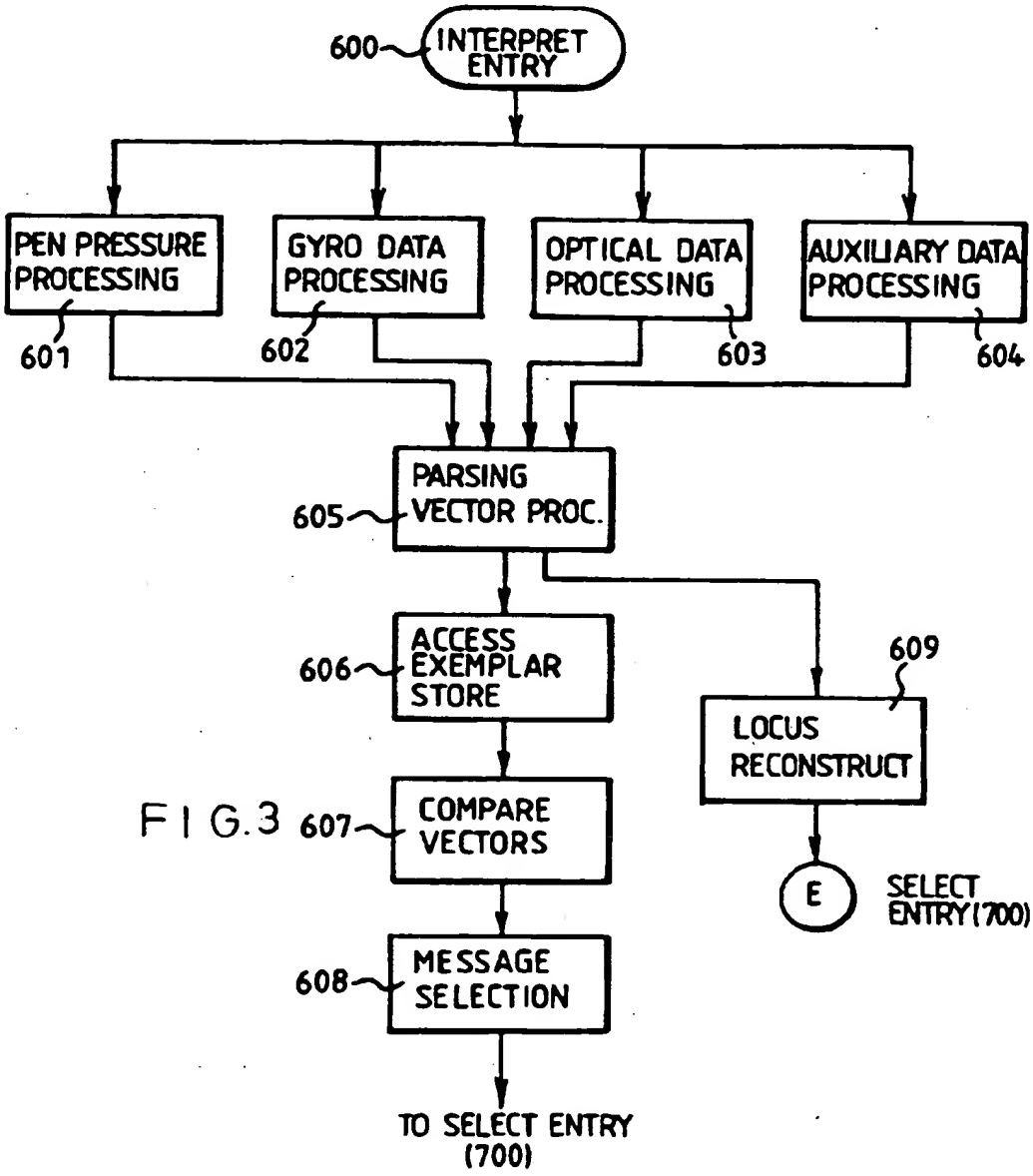
600
INTERPRET ENTRY
PEN PRESSURE PROCESSING
601
GYRO DATA PROCESSING
602
OPTICAL DATA PROCESSING
603
AUXILIARY DATA PROCESSING
604
PARSING VECTOR PROC.
605
ACCESS EXEMPLAR STORE
606
COMPARE VECTORS
607
MESSAGE SELECTION
608
TO SELECT ENTRY (700)
609
LOCUS RECONSTRUCT
E
SELECT ENTRY (700)

FIG.3

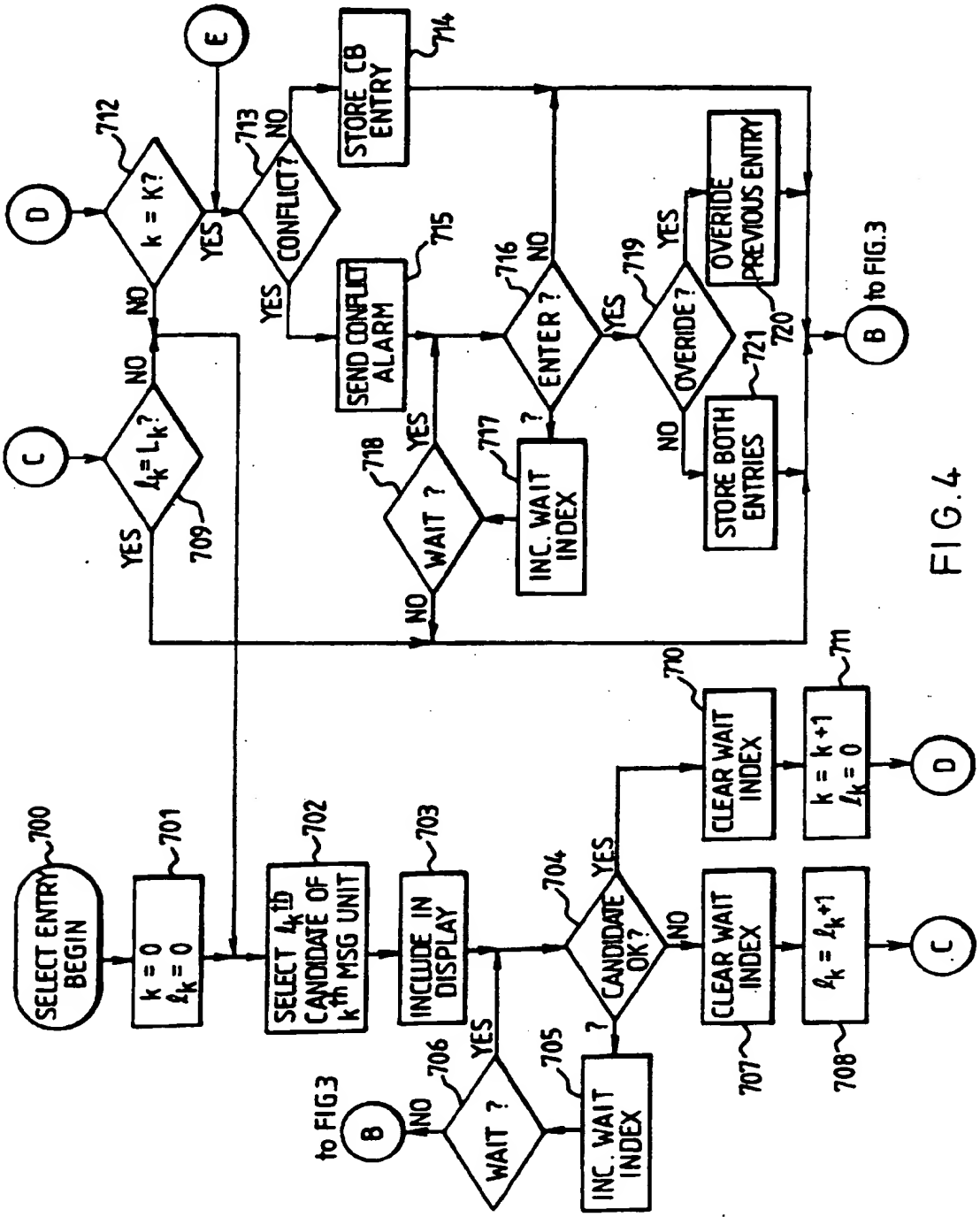
SELECT ENTRY BEGIN
700
k = 0
l_k = 0
701
SELECT l_k th CANDIDATE OF k^{th} MSG UNIT
702
INCLUDE IN DISPLAY
703
CANDIDATE OK?
704
YES
NO
CLEAR WAIT INDEX
710
k = k+1
l_k = 0
711
D
CLEAR WAIT INDEX
707
l_k = l_k+1
708
C
INC. WAIT INDEX
705
WAIT ?
706
YES
NO
to FIG3
B
l_k=L_k?
709
YES
NO
C
k = K?
712
YES
NO
D
CONFLICT?
713
YES
NO
E
STORE CB ENTRY
714
SEND CONFLICT ALARM
715
ENTER ?
716
YES
NO
INC. WAIT INDEX
717
WAIT ?
718
YES
NO
OVERIDE ?
719
YES
NO
OVERIDE PREVIOUS ENTRY
720
STORE BOTH ENTRIES
721
B
to FIG.3

FIG.4

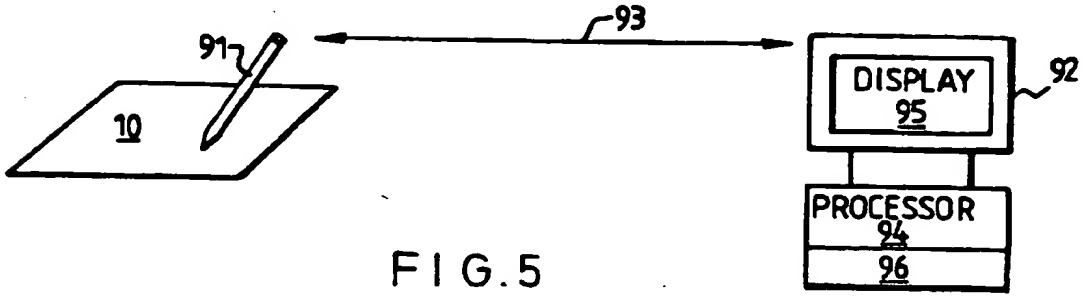
91
93
10
DISPLAY
95
92
PROCESSOR
94
96

FIG.5

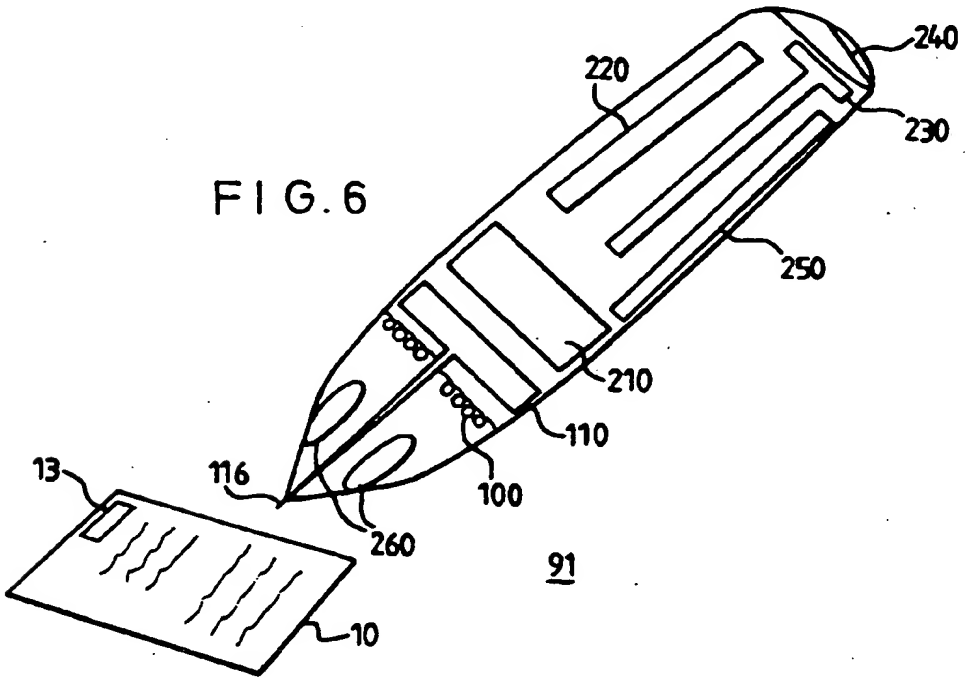
240
220
230
250
210
110
100
13
116
260
91
10

FIG.6

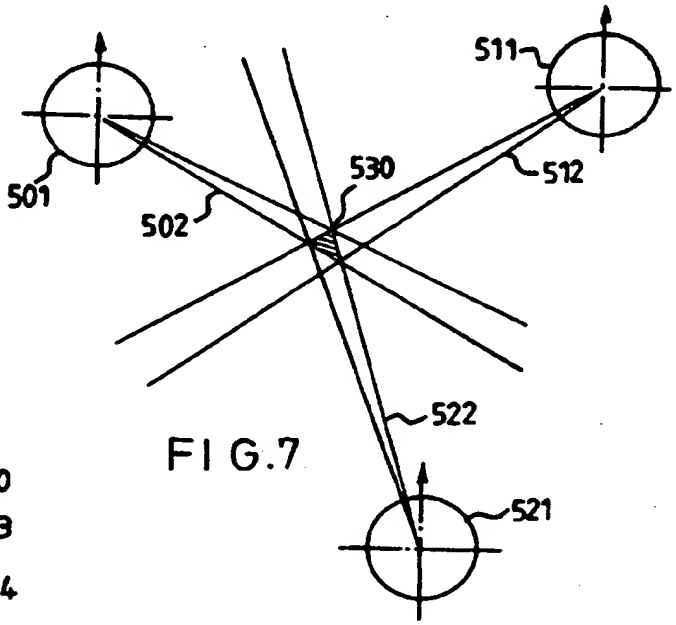

FIG.7

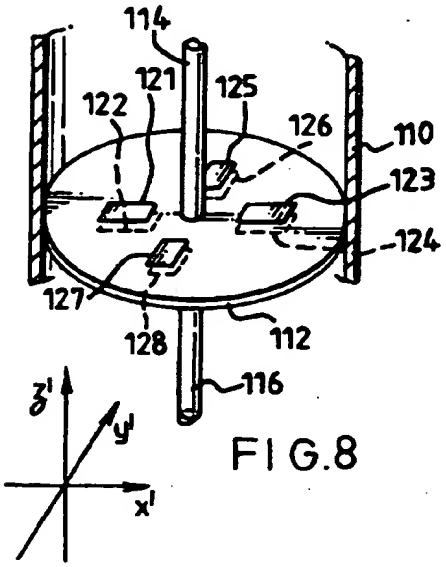

FIG.8

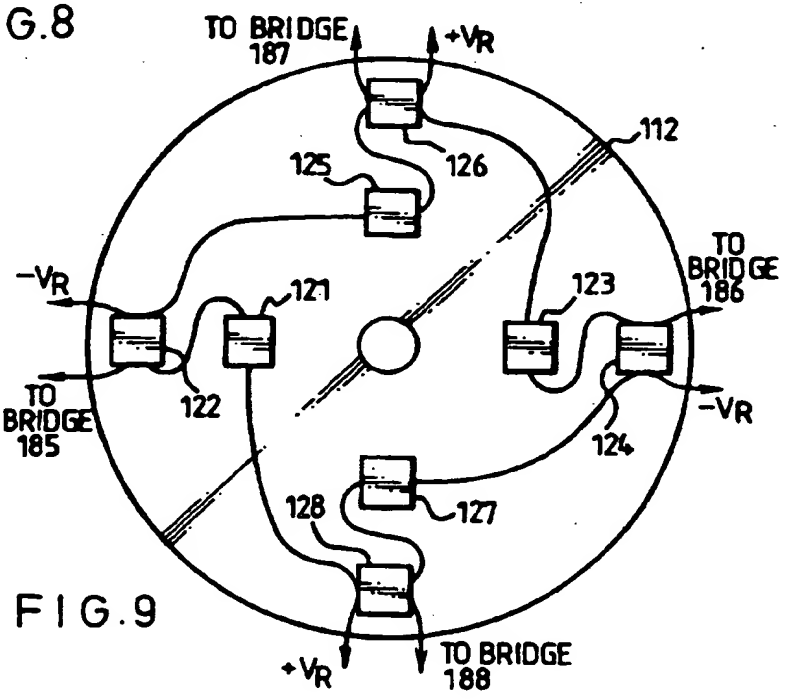

FIG.9

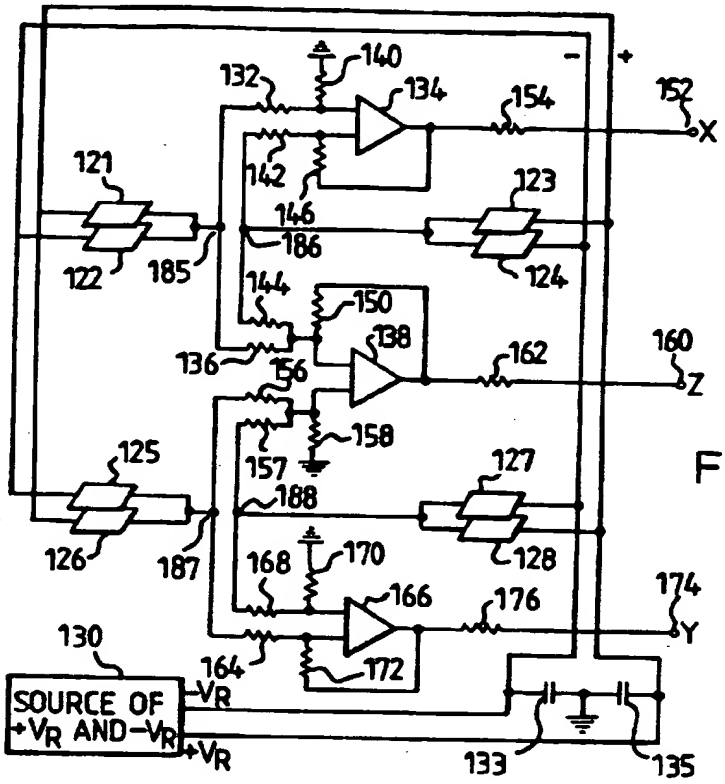
140
132
134
154
152
X
121
142
123
146
186
122
185
124
144
150
138
136
156
162
160
Z
158
157
125
127
188
126
187
168
170
128
166
176
174
Y
130
164
172
SOURCE OF
+VR AND -VR
VR
+VR
133
135

FIG.10

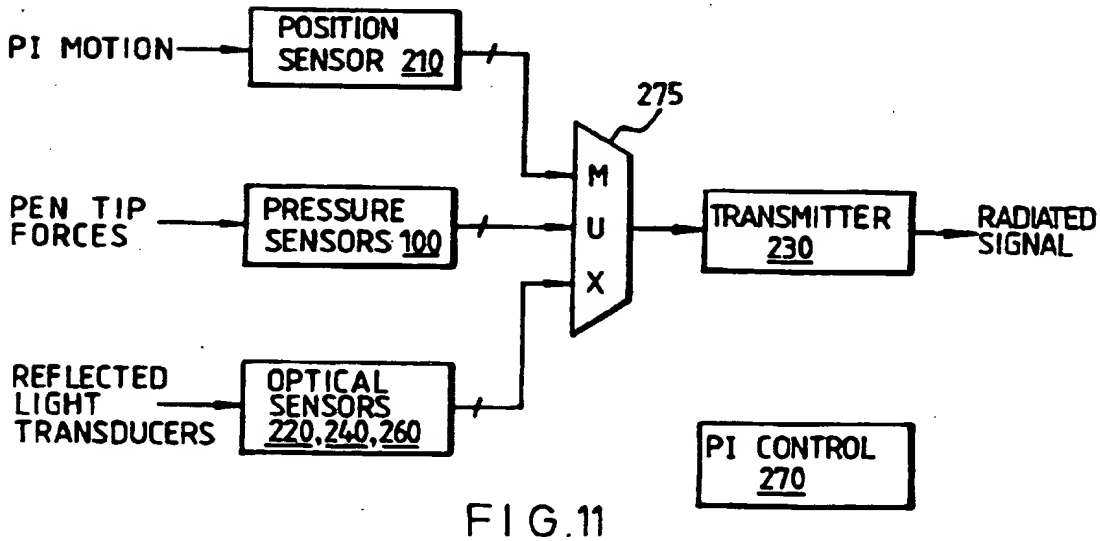
PI MOTION
POSITION SENSOR 210
275
PEN TIP FORCES
PRESSURE SENSORS 100
M
U
X
TRANSMITTER 230
RADIATED SIGNAL
REFLECTED LIGHT TRANSDUCERS
OPTICAL SENSORS 220,240,260
PI CONTROL 270

FIG.11

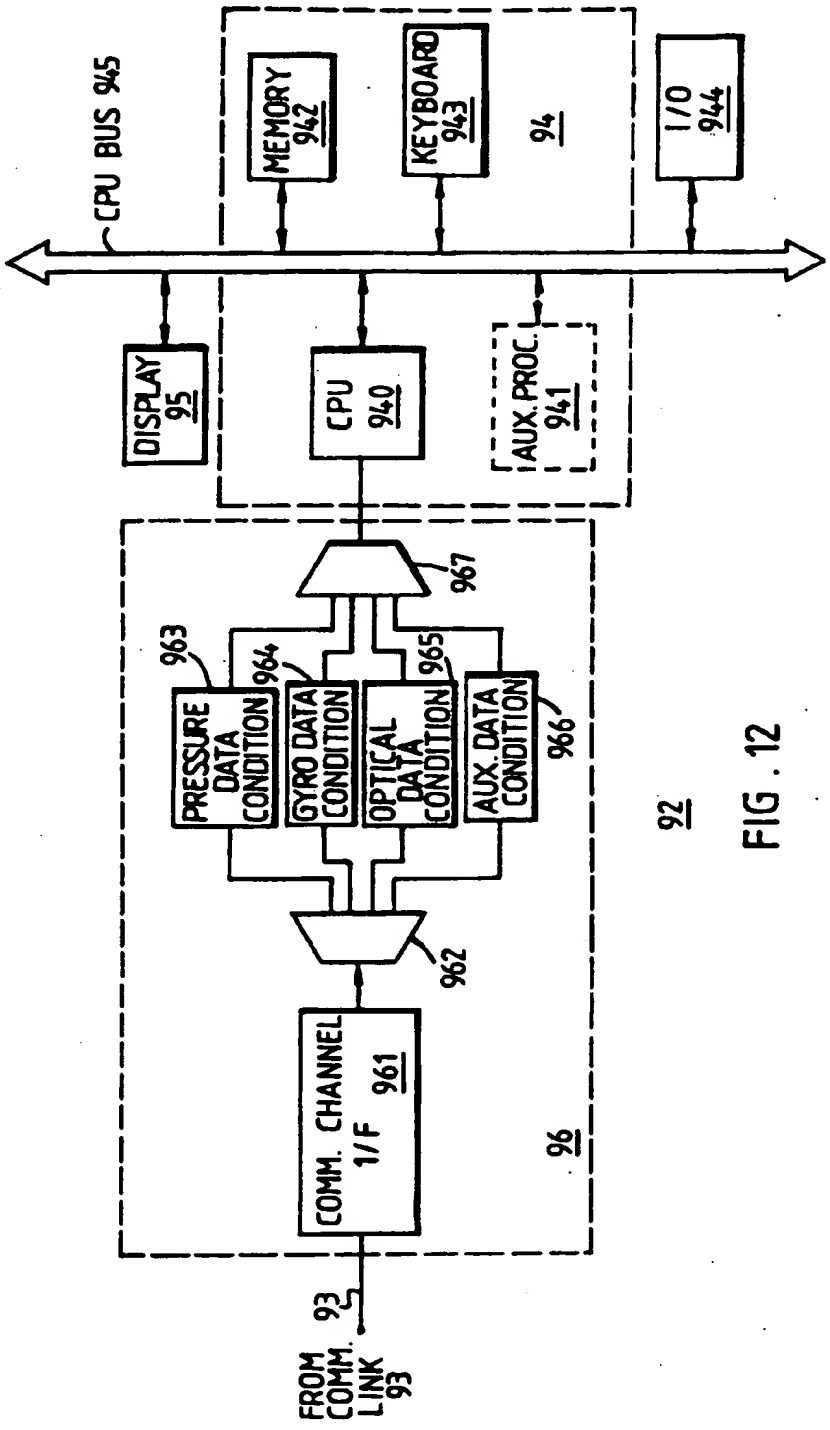
CPU BUS 945
MEMORY 942
KEYBOARD 943
94
I/O 944
DISPLAY 95
CPU 940
AUX. PROC. 941
967
963
964
965
966
PRESSURE DATA CONDITION
GYRO DATA CONDITION
OPTICAL DATA CONDITION
AUX. DATA CONDITION
962
COMM. CHANNEL I/F 961
96
92
93
FROM COMM. LINK 93

FIG. 12

GB002306669 [http://www.getthepatent.com/Login.dog/Srandall.wilcox/Fetch/DefaultLdog/GB002306669.cpc?fromCache=1part=maintoolbar=bottom]Page 10 of 44

MANUAL ENTRY INTERACTIVE PAPER AND ELECTRONIC DOCUMENT HANDLING AND PROCESSING SYSTEM

FIELD OF THE INVENTION

The invention relates to the field of handling paper documents and their corresponding electronic versions by allowing the user to interact with both versions of the same document simultaneously.

BACKGROUND OF THE INVENTION

Because people prefer paper documents for some tasks such as reading or annotating documents while electronic documents seem to be preferred for tasks such as storing, searching or communicating, it is desirable to provide document systems that maximize the user-friendly aspects of both approaches.

Unfortunately, there has been a large technological barrier between the paper and electronic documentation worlds. For example, electronic symbols may be readily converted into a printed page, but printed documents are not readily translated into compact electronic symbols. Also, the human interface with each of the mediums are radically different: writing on paper (or similar surfaces) comes naturally to children, while creating electronic documents generally requires the use of application software, keyboard, mouse, display, etc.

The present invention provides a human interface input/output device that is:

(a) small and portable,

(b) natural to use as a pen,

(c) works with both electronic and paper documents, and

(d) avoids complications and inconveniences of devices such as bulky scanners and digital pads.

As a result, users can readily create or manipulate paper documents while simultaneously making corresponding electronically-coded images of the same created or manipulated paper document. This is accomplished by means of a hand-held, pen-like instrument that can write on paper documents, simultaneously sense the writing, and interpret and enter the written markings in the electronically-coded document. Also, image sensing allows the system to identify the type of document being subjected to manually-written modifications.

SUMMARY OF THE INVENTION

A manual entry interactive handling system uses a writing instrument to manually write data on an ordinary document (that can have pre-printed information) and automatically interpret the written data so that a corresponding electronic document containing any pre-printed document information is modified by adding the written data to the stored electronic document. Both pre-printed data and the interpreted written data can be electronically displayed, the system comprises:

(a) a physical document page with a surface suitable to be written upon that can also contain pre-printed document information;

(b) a pen-instrument for writing on the physical document surface, the pen-instrument having suitable transducers for sensing both the written data and the multi-dimensional physical forces (e.g. up to three rectilinear and two rotational components) exerted on the pen instrument when writing and for reading pre-printed digital codes, and a communication link to transmit the transducer data to a base unit; and

(c) a base unit for receiving the transducer data and converting the transducer data to binary digital information suitable for processing in the base unit CPU, or another computer, for document identification and for incorporating the written information with the pre-printed document information.

In another embodiment, the transducers are capable of defining pen motion resulting from movement of the pen-instrument for other than writing such as pointing for the control of an object (such as lights).

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:

Figure 1 shows the format of a daily CB page.

Figure 2 is a flow diagram of the basic operation of a CB system.

Figure 3 is a flow diagram for procedure 600 for interpreting the pen-instrument input data.

Figure 4 is a flow diagram of the entry select procedure 700.

Figure 5 shows a CB system's major components.

Figure 6 shows the architecture of a pen-instrument.

Figure 7 shows the geometry of an infrared PI positioning system.

Figure 8 shows an arrangement of strain gauge transducers in a pen-instrument.

Figure 9 shows the interconnections of the strain gauges on the flexible diaphragm.

Figure 10 is a triple bridge circuit for processing the strain gauge transducer data and for producing x, y, and z force components.

Figure 11 shows a PI unit block diagram.

Figure 12 shows a CB base unit block diagram.

DETAILED DESCRIPTION

A. Application Areas

An interactive document system based on a pen-like instrument, or pen-instrument for convenience, has application in numerous document systems that include, but are not limited to, the following systems.

Calendar Book: appointments entered on a physical page of a calendar book are sensed, interpreted, and recorded on an electronic calendar as well.

Forms Processing: filling out of a prescribed form would automatically cause the generation of a corresponding electronic form, the paper version being kept, as needed, for legal or safety reasons. A significant cost reduction in computer data entry results.

Signature Verification: improved reliability of signature recognition obtained by storing the signature related time-course by using spatial location and pressure to characterize the signature. These parameters are not available to the forger from viewing the signature.

Interactive Fax: a facsimile system that permits users to receive documents by means of "links" similar to WebFax. This would permit the user to forward

pages to selected users by simply writing the desired destination, which when sensed and interpreted would provide the communication "link". Also, the user can annotate the document and the transmit or store the document with the annotation without the use of a facsimile scanner.

Document Editing: any paper document can be edited by crossing-out words, and by the use of typographic notation for other editing operations, or annotated, or sent elsewhere. The paper modifications immediately affect the electronic version so that the electronic version can serve as the true source document because any access of, or communications of, that document would reflect all edits or annotations.

Information Management: scanning the description of a reference document can have that paper (or its reference) stored in a designated file without photocopying.

Document Retrieval: searching of electronic databases by writing or circling a few keywords, thumbnail descriptions, or by drawing pictures, which, when interpreted, provide the data location.

Note Book: using the pen-instrument for writing notes on paper and for electronically retrieving notes previously written on paper and stored from a sequentially ordered (and/or an otherwise organized) electronic memory file.

B. System Details

B.1 Calendar Book (CB)

Because of the variety of possible document systems, as outlined in the preceding section, the details of the invention will be presented using a single application from which the extension to other applications will be readily understood by those practicing the art. For this reason, the Calendar Book is described below.

The Calendar Book, or "CB" hereinafter, looks like a conventional calendar having a page representing a segment of calendar time: a day, a week, a month, or a year. Each segment of time is further subdivided as needed: a year into months and weeks, a month into weeks and days, a day into hours and fractions thereof. Digitally coded information is printed on each page so that the pen-instrument can be used to read the pertinent digital code that identifies the page format and the segments of calendar time spanned by the CB page.

Figure 1 shows a page 20 from a CB using a one day per page format. This version allows selectable information options to be printed for each day. An area is set aside for a bar code identifier 13 for specifying the

date (year, month, and day) and user I.D. The date (year optional) is also printed in area 21. Column of rectangles 22 and 22' are available for selecting and identifying the time by entering a suitable mark (such as a check mark) in the appropriate rectangle. Column 22 and 22' have identical meanings and are provided so that two entries, only 15 minutes apart may be entered each using a half width and indicated as separate by dividing line 23. For example, an appointment with Baker is indicated for 10:00 a.m. while an appointment with Charlie is indicated for 10:15 a.m. In other words, each hour is divided into 15 minute-segments in this example. Other increments such as one-half hour and 10 minutes could also be specified. The user's choice would only be constrained by the application being served and the page size (or detail) available. The time of day is also indicated by the position of a written entry for any given calendar page format. The pen-instrument provides the writing point and the optical, the positional, and the writing point to paper pressure data to the computer for interpretation, storage and graphical display.

The graphical display can provide immediate feedback by use of an optional cathode ray tube (CRT) display. The feedback can be a simple recreation of the written message by using pen-instrument positional writing point pressure data or the interpreted written message from a cursive character recognition device using the same data. In the latter case, incorrectly recognized written data can be scratched-out or over-written.

Bar codes are read by a bar code scanner on the side of the pen-instrument. The bar code recognition device may either constantly scan in search of a legitimate bar code or operate when the positional sensors indicate that the pen-instrument is in a horizontal position suitable for reading a bar code.

B.2 Operating Mode

Figure 2 is a flow diagram describing the basic operating mode of a particular CB. The operation begins at step 500 where it is assumed that a fixed format has been prescribed and its description is stored with the configuration information for that CB. Configuration data includes calendar type, chronology layout defining time intervals, segments, and writing spaces. Also, a user list is stored against which the bar-code I.D. can be checked for validity.

At step 501, the computer checks if the pen-instrument is moving horizontally, indicating that a CB operation is about to be initiated by reading the bar-code located in area 13. If not, the system goes into a wait loop in which the pen-instrument motion is monitored. If the appropriate horizontal motion is detected, the process proceeds to step 502 in which the bar-code I.D. is read by scanning bar-code area 13 with the pen-instrument. If a valid bar code signal results, step 503 moves the process to step 505, otherwise the process goes to step 504 where an audible and/or visual alarm is set for informing the user that access is denied and the system returns to step 501. The bar-code can also be

compared with a list of authorized codes and if a match exists the CB access request is validated and proceeds to step 505. At this juncture, the pen-instrument user may try to read the bar-code again or investigate the system for the cause of the misread bar-code data.

At step 505, the electronic version of the CB page can be displayed on a screen (CRT or LCD) with the display including all prior entries on that page. The process enters another wait loop through test step 506 which checks if the writing point pressure signal exceeds threshold. If it does, this is taken as an indication that a pen-instrument operation is initiated and the process moves to step 511 where the previous wait loop index (step 507) is cleared. Otherwise, the process goes into a wait loop comprising step 507 that counts the amount of passes (or time) that the loop is traversed. Step 508 tests if a preset time has been exceeded, and if not goes back to step 506. Otherwise, the loop count index of step 507 is cleared in step 509 and the display is aborted in step 510 before returning to step 501.

Step 512 establishes the location of the written entry by using the gyroscopic rate information. By knowing the location of the bar-code page identification and by integrating gyroscopic velocity information, the location at which pen pressure is exerted is determined in step 506. This information is used to locate the corresponding electronic entry on the electronic graphical display.

From step 512, the process moves to step 600, a procedure for interpreting the message that the pen-instrument has entered on the CB

BAD ORIGINAL

GB002306669 [http://www.gatthepatent.com/Login.dog/$randall.wilcox/Fetch/Default.dog/GB002306669.cpc?fromCache=1part=maintoolbar=bottom]page 21 of 44

page. The procedure is shown in greater detail in Figure 3. The multi-sensor output signals from the pen-instrument are in electrical form, preferably as binary coded data. In this example, four data types are used and processed: pen-instrument pressure processed in processor step 601, gyroscopic restoring forces in processor step 602, optical data representative of the pen-instrument written message in processor step 603, and an auxiliary data signal representative of special cues for identifying calendar and position data from the printed CB page in processor step 604. Each processor step 601-604 extracts signal features from its associated data source. A particular written data entry may include a number of distinct message unit such as a time code derived from the printed CB page, and a written portion that may include a name and place. The message input sequence is parsed into message segments in vector processor step 605 using the various processed sensor data from processors 601-604. Thus, the presence of the writing point-to-paper pressure over an interval of time indicates writing a message segment. Gaps between pressure intervals may indicate the gap between segments. A gap can also indicate a crossing of a "t" or the dotting of an "i" after the word is written. In the latter case, gyroscopic data can confirm the backward pen-instrument motion and subsequent pen-instrument pressure coupled with either a stationary dotting action or a forward sweeping crossing of a "t". By using time-synchronized multi-sensor data, the pen-instrument written message can be used to parse the input message

into distinct and interpretable acts. Parsing vector processor 605 produces a set of vectors describing each written segment which are then identified by comparing the parsed vectors with a stored set of exemplar in exemplar store unit 607 by comparator step 606. In step 608, each parsed segment generates a set of candidate vectors corresponding to a plausible parsed message segment, which are preferably ordered in descending order of plausibility, i.e., of being the correct message segment.

The plausible candidate message units from message selection step 608 are arranged by sequence index, $0 \leq k \leq K-1$, indicating the order of occurrence of K message segments. The k^{th} message unit has L_k plausible candidates designated by index l_k, where $0 \leq l_k \leq L_k-1$ and l_k indicates decreasing plausibility with increasing value of l_k.

Because the system should provide a means for displaying a facsimile reconstruction of the written message, the output of parsing vector processor 605 also provides an output to locus reconstruction generator 609 that operates on the gyroscopic and pen pressure data to reconstruct the locus of the pen point while writing. The digitized locus is passed on to entry point E of Figure 4 for conflict resolution. In some applications, a facsimile of the original written message is preferred and in others it provides a back-up to an alphanumeric interpreted representation based on character pattern recognition techniques.

Step 700 is a multi-step process as shown in Figure 4. At step 701, the message unit index, k, and the plausible candidate index, l_k, are

cleared (k=0, l_k=0). At step 702 the l_k candidate of the k_{th} message unit is retrieved from memory and displayed graphically as trial message unit super-imposed on the appropriate CB page at the location corresponding to that written on the actual page calendar by the pen-instrument in step 703. At this point in time, the CB user is allowed to examine the trial message unit in test step 704. Three exits from step 704 are provided: a wait loop (similar to that previously described) comprising wait loop indexing step 705 and test step 706 that examines the wait loop index to determine if the process should be aborted by returning to input B of Figure 2 or returning to step 704. If the user indicates by the pen-instrument that the candidate trial message unit is correct by making an appropriate pen-instrument movement (such as simulating or actually writing a check mark if correct and an "X" make if not), the process moves to step 710 where the wait loop index is reset and then step 711 where index k is incremented and l_k is set to zero. At step 712 a test is made to determine if all message units have been displayed and, if not, the process returns to step 702.

If the user indicates at test step 704 that the trial candidate message unit is not correct, the process goes to step 707 where the wait loop index is cleared and then to step 708 where the plausible candidate index l_k is incremented. At step 709, l_k is checked to determine if all of the candidates have been exhausted and, if not, the process returns to step 702. If all

GB002306669 [http://www.getthepatent.com/Login.dog/$randall.wilcox/Fetch/Default.dog/GB002306669.cpc?fromCache=1part=maintoolbar=bottom]Page 24 of 44

candidates have been exhausted, the process returns to the beginning via input B of Figure 2.

If all message units are accounted for in step 712 (implying the graphical message on the screen is correct), the process checks to see if any conflict exists because two events are scheduled for the same time. If no conflict exists, step 714 stores the CB entry and the process proceeds to input B of Figure 3. If a conflict exists, a conflict alarm is given on the screen display or by any other means such as an audible alarm (step 715) and the user is given time to respond by the wait loop (steps 717, 718). If the response is not timely, the process aborts by returning to input B of Figure 2. If the user indicates that the new message should not be entered, step 716 aborts the process by returning to input B of Figure 2. If the user indicates at step 716 that the new entry should be entered, step 719 asks if the previous message is to be deleted and the new entry entered. If the user indicates by an appropriate signal from the pen-instrument that previous message is to be overridden, the process goes to step 720 otherwise both forms of the written message are retained in step 721.

Process 700 of Figure 4 is designed to select correctly identified candidates from a written character recognition device in step 704. However, an optional embodiment would provide for sending the processed data outputs from processing steps 601-604 of Figure 3 to an optional write simulation step 609 where the processed sensor data is used to generate a replica of the user's written message without any writing

recognition processing steps and is then displayed as a copy of the hand written message on the document. Also, both forms of written messages (an ASCII encoded interpretation of the message and a replica of the original) can be retained for future reference and selectively displayed on the CB display. By providing this option, the writing recognition process does not have to be 100% accurate.

In this manner, the electronically stored version of the CB can served as the true source document for which the paper version and trail exists in close accord with the electronic version. If the paper version begins to become unmanageable because of numerous changes, the user can obtain a new print-out of the page which may be a new page without any entries or a new page with all up-to-date entries.

Because the source exists in electronic form, electronic agents can use this information to aid the user by, for example, reminding users of appointments, performing group scheduling with other agents, reviewing the series schedule, and providing support information for a given appointment.

B.3 The CB System

The CB system 90, shown in Figure 5, includes four major hardware components:

(1) a CB page 10 or 20, as previously described;

(2) a pen-instrument (PI) 91 for providing a user with a means for entering data (both printed digital and written);

(3) a base-unit 92 for electronically processing and storing data received from the PI and including processing and conditioning electronics 96 and optional graphic screen display 95; and

(4) a communication channel 93 between the PI and base-unit.

B.3.1. Pen-Instrument (PI) 91

PI 91 is configured as a "normal" pen, i.e. a writing instrument, that is to be conveniently held and used for writing on a CB page 10 as shown in Figure 6. In addition to providing a writing point that deposits ink (or other writing medium) on to paper surface by contact, the PI incorporates a battery power source 250, and transducers for providing information for the interpretation of the user written data or printed digital information from the DB page, including the following.

Position Sensor 210: an inertial reference system is provided by a gyroscope (gyro) in which a rotating member will continue to turn about a fixed spin axis as long as no forces are exerted on the member and the member is not accelerated. Gyro attitude transducers (free gyros) are used as two-degree-of-freedom gyros that can provide an output for each of two of a PI's three attitude planes: pitch, yaw, and roll (or x, y, and z axes). Rate gyros are attitude-rate transducers that provide an output signal proportioned to angular velocity (time rate of change of attitude). The rate of change of the two axes representing the plane of the CB page are used to interpret the motion and relative position associated the use of the PI.

Accelerometers may also be used for position sensors by double integration of the acceleration signals.

When the PI is equipped with an infrared (IR) detector, a multiplicity of two or more external IR radiating scanning sources located at prescribed positions can be used to track the position of the PI by using triangulation techniques that measure the angle at which each IR scanning source illuminates the PI. Alternatively, the PI can be equipped with an IR transmitter and two or more external scanning receivers located at prescribed positions can be used to track the position of the PI by triangulation. Fig. 7 shows the geometry of an IR tracking system using three external positions labeled 501, 511, and 521. Each position has a directive scanning beam (receiving or transmitting) 502, 512, and 522 associated respectively with positions 501, 511, and 521. The shaded area, labeled 530, represents the intersection of the beams and corresponds to the estimated position of the PI.

Pressure Sensors 100: strain gauges (or other pressure sensitive transducers such as piezoelectric or reductive force transducers) connected to the shaft of the pen tip of the PI are used to record the forces applied to the tip by measuring the force exerted on four pairs of orthogonal strain gauges mounted on a flexible diaphragm that is attached to the inner walls of the PI with the pen shaft connected to and passing through at right angles to the diaphragm center. Figure 8 shows how the pressure sensors

are mounted in the PI. The operation of such a structure has been described by Crane et al. in U.S. Patent Number Reg. 29,765.

Figure 8 shows a PI cylindrical lower end 110 that houses a ball-point 116 on the lower end of shaft 114 containing the ink reservoir. The shaft, supported by a non-conducting flexible diaphragm 112 that is attached to cylindrical wall 110, causes the diaphragm to flex when pressure is applied to ball-point 116. As a result, strain gauges 121-128 that are affixed to diaphragm 112 are strained (or compressed) in accordance with the flexing of diaphragm 112 in response to the forces experienced by ball-point 116. In this manner, the forces experienced by ball-point 116 are converted into resistance changes in the strain gauges 121-128.

Because the strain gauges are paired and mounted on opposite sides of diagram 112, each pair, (121, 122), (123, 124), (125, 126), and (127, 128), tends to have opposite forces (tension vs. compression) applied to the upper and lower strain gauges. When a force is applied in the x-y plane (CB page plane) to ball-point 116, diametrically opposite pairs tend to have opposite tension and compression forces. However, when a force perpendicular to the x-y plane is applied, all pairs tend to experience similar distortions. These characteristics permit the separation of the ball point force to be resolved into three orthogonal components (X, Y, Z) where X and Y are in the x-y plane and Z is perpendicular to the x-y plane. Thus, by connecting the strain gauges 121-128 as shown in Figure

9 and applying the strain gauge connections to the multiple bridge circuit shown in Figure 10, the ball-point force is resolved at output terminals 152, 174, and 160 into the X, Y, and Z components, respectively.

The strain gauge bridge circuitry of Figure 11 is preferably mounted within the PI unit for greater noise immunity.

Although Figure 8 shows shaft 114 parallel to the z' axis and perpendicular to the x'-y' plane, the writing surface of a CB page (x-y plane) generally would not be perpendicular to the z' axis because a "naturally" held pen-instrument would from an included angle between shaft 114 and the CB page surface of less than 90°. The transformation between two coordinate systems (x, y, z) and (x', y', z') that share a common origin (the pen tip) is readily accomplished by the following vector relationship.

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} \lambda_1 & \lambda_2 & \lambda_3 \\ \mu_1 & \mu_2 & \mu_3 \\ \gamma_1 & \gamma_2 & \gamma_3 \end{bmatrix} \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}$$

where $[\lambda_n, \mu_n, \gamma_n]$, for $1 \leq n \leq 3$, represents the direction cosine vector of the (x, y, z) unit vector with respect to the (x', y', z') unit vectors (for example see Korn and Korn, "Mathematical Handbook for Scientists and Engineers," McGraw-Hill Book Co., New York, 1961, section 3.1-12, "Translation and Rotation of Rectangular Cartesian Coordinate System").

By knowing the angular orientation of shaft 114 with respect to the CB page (x-y plane) and the (x', y', z') components of force, the horizontal and vertical forces in the (x, y, z) system are readily obtained. Also, any

rotation of the PI coordinates with respect to its inertial (gyro) system may also be accommodated by use of the above transformation.

The angular rotation of shaft 114 would tend to be the same each time the PI is used by a given user. This would permit system to "learn" the proper value of the direct cosines or, equivalently, the angles of rotation by taking samples of vertical forces (z), horizontal plus vertical forces (x, z), and longitudinal plus vertical forces (y, z) when a given user respectively exerts a vertical force on the page, writes á horizontal line, and writes a longitudinal line.

The transformation of coordinates for pen tip forces is not essential because the information content of a vector is not changed by a linear coordinate transformation. However, it may be useful for the normalization of forces so that they are independent of how the pen-instrument was held. However, un-normalized forces may be useful for signature verification, because of the added parameters relating to how the pen-instrument is held and used.

Pressure sensor information is useful for recognizing when a written entry is made on the CB page and for parsing the entry into message units for easier message recognition. It is also useful for signature verification.

Optical Sensor 220: a charge-coupled-device (CCD) optical scanning transducer is used for reading reflected light variations from a scanned portion of the CB page covered by the CCD array. The transducer

is used to scan the identifying CB page bar-code. The CCD array can be located on the PI in several different areas:

(a) a linear side mounted array 220 along the length of the PI is useful for scanning a large segment of the page;

(b) a CCD array 260 at the tip of the PI pen or to one side of the tip is useful for identifying the local context of the document an exact location of the PI pen tip by recognizing pre-printed marks; or

(c) a CCD array 240 at the back (i.e. "eraser") end of the PI because it is more intuitively acceptable than a side mounted array.

Regardless of the location, the CCD sensors must be able to read digitally encoded and pre-printed information and support at least rudimentary optical character recognition (OCR). The particular choice of CCD will dictate the associated illumination requirements.

A communication path 93 is needed for linking PI 91 with base unit 92 where most signal processing of the PI sensor occurs. A wired communication link 93 can use a small tether connecting the PI to base unit 92 but a wireless connection using either infrared or radio techniques would be preferred. For this purpose transmitter/receiver unit 230 is incorporated in PI 91.

Figure 11 is a block diagram of the PI electronic system showing physical inputs to the system at left that include forces associated with motion, pen-tip forces due to writing, and reflected light for optical reading. These physical inputs are applied respectively to position sensor 210,

pressure sensors 100, and optical sensors 220, 240, and 260. The sensor outputs are multiplexed into the modulator of transmitter 230 by multiplexer (MUX) 275. MUX 275 may be either a time-division or frequency multiplexer. Overall control of the PI system is provided by controller 270.

B.3.2 Base Unit 92

Base unit 92, shown in Figure 12, communicates with PI 91, receiving sensor signals, processes the sensor signals, and drives any feedback device such as its display unit 95. The base unit is similar to a notebook keyboard computer comprising a CPU 940, keyboard 943, memory 942, and display 95. In addition, the signal conditioning unit 96 includes a transmitter/receiver as part of the communication channel interface 961 with communications link 93, and demux 962, and signal conditioning electronics (963-966) for preconditioning sensor signals from interface 961 and analog-to-digital converters for feeding digitized sensor related signals through mux 967 to the CPU for processing. The base unit can also connect with Wide Area Networks through I/O interface 944 and is able to retrieve and modify electronic versions of the user's documents. An optional auxiliary processor 941 (shown dotted) can be used to augment CPU 940 for executing written message recognition algorithms that require more intensive digital signal processing than that usually done by the CPU.

Advances in micro-electronic techniques can allow most of the functions of the base unit to be incorporated in the PI unit, particularly the

sensor signal conditioning, binary coded signal generation, and cache memory for buffering and temporary storage.

C. Other Applications and Variations

The above description of a CB system that uses a pen-instrument and base system was used as a convenient means to describe the operation of a manual entry interactive paper and electronic document handling and processing system.

It should be noted that had any of the other applications listed in section A of the Detailed Description, the basic system configuration would be the same:

(a) a physical document with a writing surface and pre-printed information;

(b) a pen-instrument for reading pre-printed (bar code) information, for sensing writing forces, for sensing pen-instrument motion, for sensing written characters, and for transmitting the information to a base unit; and

(c) a base unit for receiving information generated by the pen-instrument, interpreting the information and modifying a stored electronic version of the physical document and displaying the interpreted results to the user for acceptance or correction.

Therefore, the CB system description has served as an adequate vehicle for supporting a general manual entry interactive paper and

electronic document handling and processing system. A specialized application program package would customize the system described for each distinct application and document type.

Although the previous description of the PI and its use emphasized optical reading and message writing on a document surface, it should be recognized that the PI may also provide information from its gyroscopes and/or accelerometers for describing non-contact gestures unassociated with physical writing on a document. Two cited examples of this form of input to the system are the "check" signal indicating affirmation (correct) and the "X" signal indicating negation (wrong). Other gestures may be designed for use in a given context to indicate special messages (e.g., in editing, horizontal oscillatory motions may indicate deletion if performed over a previously written message or it may indicate an "underline" if not performed over a written message but under the message).

Selective use of color may also be used to distinguish entries from authorized multiple users by generating an I.D. code for each user's PI at the outset of writing session. A color display could readily identify the source of entries by using a different color coding for each user.

One or more buttons may be provided to initiate certain actions such as indicating that a bar code is to be read.

The PI can be used for other purposes than writing. For example, the PI can function as a pointer or as a "master mouse" that drives a slave

mouse cursor on a graphic display or for navigating 3-dimensional virtual reality displays. A button can be used as a mouse button.

Yet another variation of the PI can have a receiver for receiving the output of multiple (infrared) transmitter for position location using triangulation techniques. This variation could be used for blackboard writing or other large surface writing and display boards.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes (as described above) may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

1. A manual entry data handling system for storing data representative of motion of a manual instrument in a multi-dimensional space, the system comprising:

(a) a first communication channel;

(b) a manual instrument having at least one transducer for sensing self motion in the multi-dimensional space, generating a signal representative of the self motion, and a first communication channel interface for accepting and sending the signal over the first communication channel; and

(c) a base processing unit with a control processing unit, (CPU), a first communication channel interface coupled to the first communication channel for accepting the signal sent by the manual instrument over the communication channel and for storing a representation of the signal into a memory under control of the CPU so that the stored representation can be retrieved for reconstructing the self motion of the manual instrument.

2. The system of claim 1 wherein the base processing unit is contained within the manual instrument and further comprises a second communication channel interface for coupling the CPU to an external bus for control and data communications to other devices.

3. The system of claim 1 wherein the manual instrument transducers for sensing self motion are rate gyroscopes that generate a set of electrical signals, each electrical signal representative of a component of motion in the multi-dimensional space.

4. The system of claim 1 wherein the manual instrument transducers for sensing self motion are accelerometers that generate a set of electrical signals, each electrical signal representative of a component of motion in the multi-dimensional space.

5. The system of claim 1 wherein the manual instrument transducers for sensing self motion are a combination of at least one rate gyroscope and at least one accelerometer for generating a set of electrical signals, each electrical signal representative of a component of motion in the multi-dimensional space.

6. The system of claim 1 further comprising at least two infrared receiving scanning stations located at prescribed positions external to the manual instrument for scanning the area in which the manual instrument is located, and wherein the manual instrument transducer for sensing self motion is an infrared transmitter for transmitting an infrared signal that is detected by the infrared receiving stations for determining the manual instrument position by triangulation techniques.

7. The system of claim 1 further comprising at least two infrared radiating scanning sources located at prescribed positions external to the manual instrument for illuminating the manual instrument, and wherein the

manual instrument transducer for sensing self motion is an infrared detector for detecting the illumination by each external infrared source for determining the manual instrument position by triangulation techniques.

8. The system of claim 1 wherein the manual instrument is for use as a writing instrument.

9. The system of claim 1 wherein the manual instrument is for use as a pointer.

10. A manual entry interactive document handling system using a writing instrument to write data on a document and interpret the written data so that a corresponding electronic document is modified by incorporating the written data, the electronic document data suitably encoded as binary data, the system comprising:

(a) a physical document page with a surface suitable for writing upon;

(b) a communications channel;

(c) a pen-instrument having a writing point for writing data on the physical document page using a visible writing medium, including a set of transducers for sensing the written data by generating electrical signals representative of physical actions exerted or the pen-instrument when used for writing, and a communications interface for sending the electrical signals over the communications channel; and

(d) a base processing unit including:

(i) a communications interface for interfacing with the communications channel and receiving the electrical signals from the pen-instrument,

(ii) a signal conditioning unit for converting the electrical signals into binary coded data;

(iii) a central processing unit (CPU) with a memory for programmable control of the base processing unit for storing and modifying documents stored in the memory in conformance with the electrical signals received from the pen-instrument.

11. The system of claim 10, wherein the physical document page has pre-printed data in support of an application for which the physical document page is intended and a corresponding image stored in the base processing unit.

12. The system of claim 11, wherein the physical document page has a visual binary encoded signal for identifying the application, the visual binary encoded signal suitable for reading using an optical sensor located in the pen-instrument.

13. The system of claim 12, wherein the physical document page is a calendar page and the visual binary encoded signal identifies a calendar segment as the calendar segment represented by the physical document page.

14. The system of claim 13, wherein the document page has a second visual binary encoded signal suitable for reading using an optical

sensor located in the pen-instrument for identifying a location of a prescribed application area on the physical document page.

15. The system of claim 14 wherein the second visual binary encoded signal identifies the location of a prescribed application as a calendar segment that is a fraction of the physical document page calendar segment.

16. The system of claim 10 wherein the physical document page has a visual binary encoded signal for identifying a user associated with the physical document page.

17. The system of claim 10 wherein the pen-instrument visible writing medium is ink.

18. The system of claim 10 wherein the pen-instrument visible writing medium is pencil-graphite.

19. The system of claim 10 wherein the pen-instrument visible writing medium is chalk.

20. The system of claim 10 wherein the pen-instrument further includes an optical sensing device for reading a visual binary encoded signal imprinted on the physical document page.

21. The system of claim 20 wherein the optical sensing device is a charge coupled device (CCD).

22. The system of claim 10 wherein the pen-instrument set of transducers is a set of accelerometers.

23. The system of claim 10 wherein the pen-instrument set of transducers is a set of rate gyroscopes.

24. The system of claim 10 wherein the pen-instrument set of transducers includes at least one rate gyroscope and at least one accelerometer.

25. The system of claim 10 wherein the pen-instrument further comprises a pressure transducer for generating an electrical signal representative of the force applied to the pen-instrument writing point when writing on the physical document page surface.

26. The system of claim 25 wherein the pressure transducer is a set of strain gauges arranged to generate a set of electrical signals representative of three orthogonal components of force applied to the pen-instrument writing point with two-orthogonal components in the physical document page surface and a third perpendicular to the same surface.

27. The system of claim 10 wherein the pen-instrument further comprises an optical array sensor located near the pen-instrument writing point for reading a local optical image in the vicinity of the pen-instrument writing point.

28. The system of claim 27 wherein the optical array sensor is a charge coupled device array.

29. The system of claim 10 wherein the communication channel is a radio link.

30. The system of claim 10 wherein the communication channel is an infrared channel.

31. A method for manual entry of data into a document handling system using a pen-instrument having a writing point for writing data on a physical document and interpreting the written data so that a corresponding electronic document is modified by incorporating the written data, the physical document having a prescribed printed format including a bar code for document identification, the document handling system having a stored electronic copy of the physical document, the pen-instrument having means for detecting a set of physical forces acting on the pen-instrument when writing, the set of physical forces for describing the written data on the physical document including the detection of forces acting on the pen-instrument writing point, and means for reading the document identification bar code, the method comprising:

(a) reading the bar code using the pen-instrument;

(b) moving the pen-instrument to an initial location on the physical document at which writing is to begin as indicated by forces acting on the pen-instrument writing point;

(c) computing the initial location from the forces required to move the pen-instrument from the bar code location to the initial location;

(d) writing on the physical document using the pen-instrument writing point and detecting a set of forces acting on the pen-instrument while writing;

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(e) reconstructing the written data electronically from the detected set of forces;

(f) superimposing the reconstructed written data on to the stored electronic copy of the physical document.

32. The method of claim 31 wherein the reconstructed written data is representative of the writing point locus traversed on the physical document during writing.

33. The method of claim 31 wherein the reconstructed written data is an alphanumeric interpretation of the written data.

The Patent Office

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Application No: GB 9622632.9 **Examiner:** M. G. Clarke
Claims searched: 1-30 **Date of search:** 11 February 1997

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2Y YTA; G1N NAGA10, NAQB

Int Cl (Ed.6): G06K 11/18

Other: ----------

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2270740A	The Pen Corporation Ltd - whole document	1 at least
X	US5434371	assigned to A.T.Cross Co - whole document	1 at least
X	US5294792	assigned to Texas Instruments - whole document	1 at least
X	US5247137	Mark Epperson - whole document	1 at least
A	US4513437	assigned to IBM Corpn. - whole document	
X	US4070649	Sanford J. Wright - see esp. Figs. 1-7	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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